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THE PUBLICATION OF RESEARCH

Lecture by

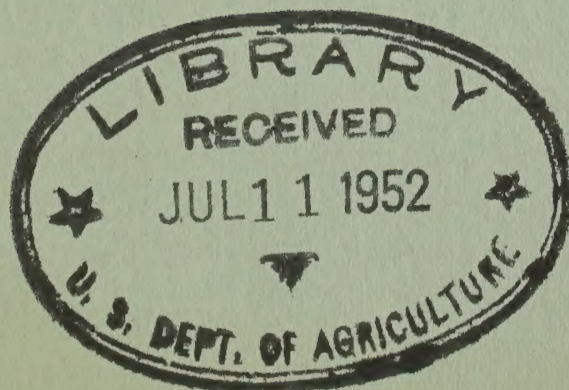
E. W. Allen, Chief, Office of Experiment Stations
United States Department of Agriculture,

before the class in

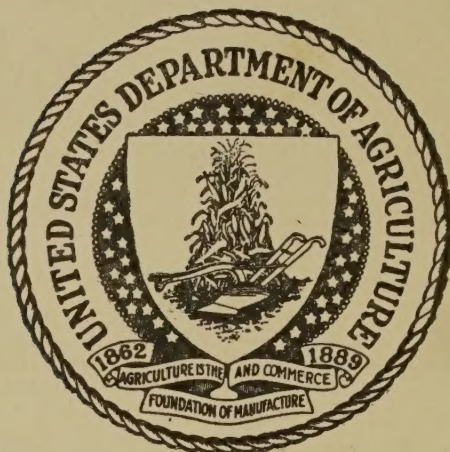
"The Nature and Method of Research"

Graduate School, Department of Agriculture,

Feb. 11, 1925.



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BOOK NUMBER

826337

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THE PUBLICATION OF RESEARCH *

The ultimate aim of research is publication. It may be deferred, but it is due eventually if the research has been successful. To some this final task, like the end of a poor cigar, is often very bitter. But in research the end is even more important than the beginning, and quite as deserving of being well done as any other part of the work.

The idea that in writing a paper "anything will do," and that it is a weakness and a waste of time to be fussy about it, will rarely bring a creditable printed report or stamp the author as a painstaking investigator. Writing is, to some extent, a special aptitude or acquirement, and those with whom it is not a native ability can do much to improve it by practice and by taking pains. It is especially important for the scientist, because it is his means of communication and, to a large extent, of his influence. Hence his attitude toward the task should be right.

IMPORTANCE OF MERITORIOUS PUBLICATION.

Publication is a serious matter because of the permanence of the record. A printed paper can not be recalled or retracted as the spoken word can; it

*Dr. Allen's lecture was considered so interesting, stimulating, and helpful to the small group to whom it was delivered that it was deemed desirable to make it available to scientific workers who prepare manuscripts for the Journal of Agricultural Research or other publications of the Department of Agriculture. His consent was therefore secured to allow its appearance in this form for wider distribution. (M. C. Merrill, Assistant Director of Publications, In Charge of Scientific and Technical Manuscripts, U. S. Department of Agriculture.)

stands for all time. Of course, a statement may be explained or modified after it has been published, but it is difficult to reach all readers of the original, and the correction may be overlooked in future citation.

For us in the Department of Agriculture, which stands so close to the public on the one hand, and to various branches of science on the other, the obligation to publish the results of investigation in suitable form is no less heavy than that of making the work itself exact in method and deduction. The manner in which this is done will reflect not only upon the individual worker but upon his organization and the Department as a whole.

Unfortunately, much scientific writing of the present time is loose and indefinite in its expression, verbose often to the point of being tedious, and out of harmony with the ordered, exact, and logical nature of science itself. It is the subject of much unfavorable comment not only by the press but by other classes of writers. Sir James Barrie recently remarked that "The man of science appears to be the only man who has something to say just now, and the only man who does not know how to say it." Apropos of certain "diffuse" and "overloaded" papers presented at the British Association a few years ago, the London Times pointedly remarked that "Science should not disdain the art of presentation." The publications of the Department and the experiment stations have long been popular subjects for newspaper gibes; sometimes partially merited and frequently a reflection on the reporter for his lack of understanding or for being so far behind the times.

While we can never hope to wholly escape such comment, we can take away such ground for it as lies in faulty writing or failure to adapt the text to the audience addressed. For it is all too true that scientific men are often unsuccessful writers, not only for popular reading but for their fellow specialists. This is partly because their training has not been in that line and their minds have been schooled to analytical habits, and partly because they are not willing to take sufficient pains or exercise critical judgment in selecting and presenting their material.

THE PURPOSE OF WRITING.

The purpose of writing is not only to express ideas, but to communicate them to others. Science is not inherently dull, heavy, and hard to comprehend; it is essentially fascinating, understandable, and full of charm. It is simple, after it has been worked out, and is capable of being stated in concise terms easily understood. But to succeed in conveying ideas correctly and in a readable way requires considerable effort on the part of most of us. It calls for time to do it well. It is just as important as making more experiments, although the worker may not like it as well, and it is quite as worthy of his best effort. He should take care not to overestimate his ability to dash off a research paper at odd times.

The aim in publishing research, as well as in carrying it on, is to leave the field clearer than you found it. If that can not be done it is doubtful whether a scientific paper is justified. There can not be clear writing without clear thinking, and when one learns to write clearly, he will in the process learn to think clearly. Indeed it may be doubted whether thought and its expression can be

separated. Vagueness or turbidity of language usually indicates similar qualities in the thinking. The attempt to express a matter clearly in writing thus helps in the process of clear thinking. Bacon wrote that "Reading maketh a full man, conference a ready man, and writing an exact man."

OBLIGATION TO THE READER.

Clearness.

Since the object of writing is to communicate information, the writer may well give special attention to being intelligible. The audience addressed needs to be kept in mind and the language adapted to the reader. Sir Clifford Allbutt lays down the good rule to "take pains with yourself first, then with your reader"; and says further: "A writer who writes to convince and not merely to see his name in print must learn to lay his mind alongside that of his reader."

In other words, it is necessary to understand and keep in mind the point of view of those it is desired to reach, the mental background with which the new facts must be harmonized. The writer must know how to present his facts and arguments so that they will fit into the reader's experience and what he already knows. The reader may know something about the subject, but he doesn't know the point of view from which it was taken up, the purpose, and the reasoning, or how the work further clarifies the subject, unless these things are presented in their proper setting.

Clearness is absolutely essential in technical writing. It is not enough to use language that may be understood-- it is necessary to use language that can not be misunderstood. Whether we agree with the author or not, we should never be in doubt as to

what he means.

One of the first requisites to clearness of expression is mastery of the language--not in the mere passive sense of avoiding errors, but positively, as a flexible medium for the exact, unmistakable expression of thought. The choice of words, the order in which they are arranged, the sequence of clauses composing sentences, and, finally, the arrangement of sentences in a paragraph are important features in effecting clearness.

Words are the vehicle of language. They are to impart ideas; hence care needs to be exercised in their choice. There are fine shades of meaning to be observed. The use of the right word will save considerable explanation and thus assist brevity. "The wrong word derails the thought; the needless word is an obstruction." The cultivation of a fairly broad vocabulary is desirable, but it is preferable to repeat the same word, if necessary to make the meaning clear, instead of adopting one that does not fit, for the sake of variety.

Lavoisier, writing on the expression of ideas in 1789 said: "Every branch of physical science must consist of three things: the series of facts which are the objects of science, the ideas which represent these facts, and the words by which these ideas are expressed. Like three impressions of the same seal, the word ought to produce the idea, and the idea to be a picture of the fact....As long as precise terms are lacking we can only communicate false or imperfect impressions of these ideas to others."

Having something to say, therefore, say it in your own way, provided you use good diction, the right word, and a simple form of expression. Above all, make your meaning clear. Read over each sen-

tence to see if it expresses what you desire to say. Eliminate each word that is not necessary to the sense or the spirit of the article. Words are only useful for expressing ideas; fine writing and high-sounding phrases have no place in technical articles. Choose your words with care. Make each sentence convey an idea, and don't try to put more than one idea in a sentence. Punctuate so as to bring out your meaning; the punctuation is a part of the writing.

On this subject of lucidity in writing, I should like, even at the risk of some repetition, to quote from Dr. Erwin F. Smith of this Department, who has given some remarkably good advice on writing.* He says:

"Clarity is the soul of truth, and especially in science there should be an idea behind every expression, and this idea should be stated as clearly as language permits....There are various ways of saying things, but only one best way. Nevertheless, to read the contributions of many scientific men one would suppose they must think any method of expression sufficient, even the most clumsy and ambiguous. Yet such is not the case. In spite of this motley array of bad writers, it is best that subject and predicate should agree,**** and especially that each statement should be susceptible of but one interpretation!

"Every paragraph and sentence in your paper should receive careful and repeated consideration, first, as to whether it tells the exact truth; second, as to whether it is absolutely clear, i.e., will convey the same meaning to all as to yourself;

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*Bacterial Diseases of Plants, by E. F. Smith, pp. 643-7

third, as to whether it is complete, or requires various additions or qualifications (--science is an eternal qualification); fourth, as to whether the sentences in it are entirely logical and move convincingly toward your final conclusions. These things can be determined only by repeated readings and much pondering....Occasionally there is a person who can write a thing as it should be the first time trying, but I have known only one or two such persons. Generally, easy writing is hard reading. Darwin sometimes recast his paragraphs a dozen times, and most of us may expect to reach a good style, if at all, only by dint of much labor and repeated rewriting. Yet who can doubt that it is an end worth all it may cost?"

So remember the reader. Be sympathetic toward him. He must make some effort, but he is not bound to follow you through. The writer has not the same hold on his audience that the speaker has. You may have to see it through if you get into a dull or unprofitable lecture, but the reader does not have to stay by an article that is hard to follow, badly put together, or tedious in its extravagant length. The author must interest and hold the reader if he expects to accomplish his purpose in publication. If a paper is direct and understandable, and has something worth while to say, it will be readable and interesting--often entertaining. If it is not interesting it will not be read, or only skimmed as a matter of duty. It is not always the fault of the public or of brother scientists, if they are not familiar with your published work; a part of the burden rests on you.

Study to communicate the results of research in a way that will involve the least effort on

the part of the reader to take them in. Spencer said that "Those are the most effective modes of expression which absorb the smallest amount of the recipient's attention in interpreting the symbols of thought, leaving the greatest amount for the thought itself." Technical articles naturally require rather close attention in reading, but it is

poor writing when a sentence or a passage must be reread two or three times to get at its meaning. Writing that leaves the reader's mind in such a condition that it can uninterruptedly follow the meaning of the paper without being conscious of the words has been described as good style. Huxley's idea of style was "to say that which has to be said in such language that you can stand cross-examination on each word."

Brevity.

Brevity is another important quality of a technical paper. This does not mean that the presentation should not be adequate to a clear understanding of what is reported and ability of the reader to judge the merits of the contribution; but the length should be proportionate to the actual contribution. Nowhere are more skill and judgment required.

A publication is not judged by its length but by the message it carries. The amount of well-directed and well-digested work it represents, the discrimination shown in distinguishing between the important and the relatively unimportant, and conciseness in presenting the essential features are its claim to recognition.

Verbosity and diffuseness suggest a possible lack of really important matter to fill out the space, or at least that the writer has not di-

gested what he has to say. As one writer puts it: "Verbosity is a sign either of carelessness or of a lack of time to take care."

The question of what to include will be determined to some extent by the character of the publication; but whether it is a technical or a semi-popular one, the question of what to leave out will be one for very careful consideration, which frequently can not be settled at the first writing. On review it may be found that considerable may be left out without sacrificing anything really essential. Descriptions and statements of facts gain force by brevity and by sticking quite closely to the real kernel of the subject.

As a rule, the more definitely a fact has been established by an investigation, the more directly and simply it can be presented. It is the doubtful ones that have to be hedged about with explanations, qualifications, and cautions.

On this subject of brevity Dr. Smith says:

"A good rule is never to use two pages for a subject that can be compressed by a little thinking into one. The generality of men use more words to express an idea than are actually necessary, if the best words had been chosen. Study the meaning of words, their shades of meaning, and re-write a subject twenty times, if necessary, to state it cogently and with brevity. Remember: nearly everybody will read a brief statement on an interesting subject, while only the most phlegmatic and determined will hold themselves to a long-winded one. You will more than treble the number of your readers by halving your paper!

"Moreover, for the necessity of those who can't spend even the minimum of time necessary to read a short paper, and for the convenience of everybody, especially of the foreigner, it is your solemn duty to sum up the substance of your contribution in a series of brief conclusions which everyone will read, and which, if well put, may induce many to turn back and read your whole paper."

Style.

The style of the technical paper should be simple, straightforward, and dignified. It should suggest neither a fairy tale, a sensational newspaper story, nor a sermon, but rather a simple, unaffected, and uncolored account of work done and its application. Accuracy and clearness ought never to be sacrificed to a supposedly more popular style. The presentation should be such as to win the reader's confidence in the thoroughness and reliability of the work reported.

Accuracy of fact and statement is, of course, a primary requirement in technical writing. Carelessness is intolerable, a reflection on the author which can not be shifted to the stenographer or the printer, even though these may be found at fault. The investigator who is careless in reporting his work lays himself open to the suspicion that he may be careless in his experiments, in taking data, and even in thinking about them.

PREPARATION OF MANUSCRIPT.

With these things in mind, what should be the method of preparing for publication? I have no

new receipt, no suggestion that has not been made by others, but with this acknowledgment I may attempt to put into form some of the essentials we have been discussing.

In presenting a scientific paper or a bulletin the author says, by inference at least: "Here is the product of my labors upon this subject, taking advantage of what others have done and building upon that foundation. I present it because the work has reached a stage which marks an advancement worth recording. I give it to you in a simple and straightforward form which will enable you to understand the status of the subject, my contribution to it, and its bearing or application. It is the product of my investigation and my mature judgment. I am ready to stand by my work and to be judged by this account of it."

Schopenhauer divided writers into three groups. The first and largest group wrote without thinking; the second thought and wrote at the same time; and the third group, a very small one, thought before they even began to write.

Outline or Plan.

It is a good idea, therefore, to begin with the making of an outline or plan to be followed in constructing the article. Order is the first law of nature; hence an account of research dealing with a study of nature ought to reflect this quality in its arrangement. One of the first requirements is that the paper should be systematic, orderly, and logical in its method of presentation, progressive in its effect, so that the course can be followed and interest

will cumulate to the very end.

The Title.

First in order will come the title. This can not always best be determined at the beginning, but it has to be provided for and so may be considered here. It is a matter of much more importance than is sometimes thought to be. Of course there is a limit to what can be put into a title, but it should be specific and descriptive as far as it goes. Bibliographers complain bitterly of misleading or incomplete titles, and as bibliographies, abstracts, and indexes must be depended on for finding a paper after it is a few years old, an inadequate title is one means of burying a piece of research.

There have been several articles in Science recently on the proper wording of titles of scientific papers, especially from the standpoint of the librarian and bibliographer. In one of these an earnest plea was made for such clear and definite titles as will enable the accurate cataloging of articles, so that the investigator must find them in his search for the literature.

The Introduction.

Next will come the introduction, which, in an account of research, would set forth the problem and give a brief review of the recent literature bearing on the subject. Such a review should rarely constitute a monograph of all that can be found, as is sometimes the case, but be sufficient to show the status when the writer entered the field and the place where his work began. This

will naturally make clear what the specific object of the research was--whether the adding of a new fact or idea, or a further interpretation.

This introductory matter will usually constitute a relatively small part of the article and be confined to what is strictly pertinent to the subject under discussion. It should not suggest what the old lady referred to as a preramble. Dr. E. E. Slosson of Science Service gives the following advice in this connection: "Don't back up too far to get a running start. Remember the man who wanted to jump over a hill. He ran a mile to work up momentum and was so tired when he got to the bottom of the hill that he had to sit down and rest. So will your readers be. Ninety per cent of the manuscript that I have handled in twenty years as an editor would have been improved by cutting off the first page or paragraph. Yet authors, like hens, kick on decapitation."

Body of the Article.

We are now ready for the account of the investigation itself. Begin at the beginning, and let the account unfold itself in a systematic, logical way, as a verbal account of some experience would, but with the possibility of doing even better. When we are talking we often revise a somewhat confused statement by "that is to say" or "in other words," which indicates dissatisfaction with the way the matter has been put, and that in translating his thoughts into words the speaker has clarified his own thinking. This correction will usually be taken care of in the revision.

The reader will naturally be interested in a brief statement of the plan of procedure, the method employed, an indication of the scope of the study, and conditions under which it was done. The account will aim to show that the writer had a clear purpose in starting the work, realized what he was going after in his investigations, has the facts arranged in his own mind, and has studied them so that he can impart them to others and draw warranted deductions and conclusions.

To quote Dr. Slosson again, "Don't overestimate the reader's knowledge, and don't underestimate the reader's intelligence. He may not know as much as you do about this particular thing--let's hope not, anyway--but otherwise he may be as bright as you are--let's hope so anyway."

"Don't forget that your reader is interrupting you every ten lines to ask 'Why?', 'What for?', or 'Well, what of it?', and if you don't answer his tacit questions he will soon stop reading."

"Don't shoot in the air. Aim at somebody. You may miss him but you are more likely to hit somebody else than if you aim at nobody. Look out of your window and note the first person coming along the street. Imagine yourself stopping the man or woman on the sidewalk and, like the Ancient Mariner, holding his or her attention till you have told your tale to the end."

Analyze the subject carefully and break it up into parts. Use center heads and side heads in the text to divide it and express the relation of parts. This helps in the progressive arrangement and assists the reader to follow. Paragraph freely, separating different points in this way and bringing together things which belong together.

This makes the page look less solid and makes reading easier.

As far as possible finish up each topic or phase of the subject as you go along. Do not revert to it further on in the text to add some new point. This makes confusion. When comparisons are made between different parts of the paper refresh the reader's mind sufficiently so that he will not necessarily have to turn back and reread in order to understand the new point.

Data and Tabular Matter.

A preliminary step toward writing is the preparation of the data. It is often possible to work up the data as the investigation progresses from one stage to another. This is helpful in connection with deciding on the next steps. Before writing, the results will need to be critically reviewed to determine what they show and how they can best be arranged. The arrangement of data is an important part of the task of presenting the matter to someone else.

This occasion will be one for sifting, condensing, and summarizing. It is a selective process. I know there are those who contend for the publication of all the important data, so that readers may not only follow the author's reasoning but be able to check up critically on his deductions. Some writers insist on a practical reproduction of their notebooks, but this seems rarely warranted or necessary. Liberality should be exercised, of course, but the permissible liberality is determined in no small measure by the character of the article. The main object is to record matters which have permanent value, confessedly a matter

of good judgment in which there is perhaps as much danger of overestimating the importance of details as of leaving out too much.

The object of a table is to present a picture of the data, as complete in itself as possible. The purpose of tabulated data is not alone to record it, but to clarify the subject--to present the matter more clearly and concisely than it could be presented in the text. A table is a difficult thing for many people to make and for others to understand, particularly if it is unduly complicated or improperly constructed. The reader should be prepared for it by a text which leads up to it with a simple and direct explanation and a suitable title which tells what it is about. There is often room for improvement in such headings. Sometimes tables are designated merely by number. Do not cover too many different points in a single table. This makes the table complicated and leads to confusion, and it often results in including things which must be referred back to in the discussion several pages beyond. Long tables are apt to be confusing.

Try to avoid putting different units in the same column, as pounds, tons, dollars, etc. Sometimes this is necessary, but usually it can be avoided by turning the table about. As far as possible, tables ought to be self-explanatory, but sometimes the different treatments or variables are indicated by letters or numerals requiring reference to the text to supply the information, which usually is difficult. The table ought to clearly indicate the essential variables.

Don't forget that the reader will expect the

author to make some explanation of what he considers a table shows, or how it prepares for what is to follow. It was not unusual in the past to "let the results speak for themselves," presenting them with no attempt at comments or comparison. Frequently this reflected a difficulty of interpretation, and so raised the question as to why such data should be inserted if the author himself was not able to make anything out of them.

Avoid qualifying unnecessarily or too extensively. The aim should be to make fairly definite statements regarding the teachings of the investigation. These may be limited in their scope, but they ought to be direct, so that they can be understood. This is true whether they are conclusions, generalizations, or tentative suggestions. It is important to make the meaning clear, to be cautious and reserved, keeping well within the facts; but there is such a thing as being too cautious and too reserved, as if the author were not sure what he believed. It is a good rule to say what you have to say so people will give you credit for your suggestion or deduction: if not, it will be difficult to establish claim to originality later when someone else makes a positive announcement.

Illustrations.

A good illustration is often the quickest way to convey an idea. Frequently it will do the work of a whole page of description. The same is true of the presentation of results in graphic form, provided such graphs are not so complicated as to require an undue amount of study. The object of illustrations is to illumi-

nate the text but not to embellish it-- to make it more intelligible, or to give a more definite impression. There is sometimes a tendency to overillustrate, which is a decided disadvantage in a scientific article. Aside from the expense this entails, it is confusing to the reader to be constantly running upon illustrations which are naturally supposed to have some bearing on the text, but after some waste of time are found not to have. Where possible there should be a reference to each figure or illustration in the text, and each figure should have a legend or title, telling what it illustrates and explaining it where necessary.

Conclusions.

The reader will expect some conclusions. He may be suspicious if there are too many or if they are too far-reaching. The author here has the opportunity of crystalizing the results and showing how they clarify the subject. The important points developed in the investigation should be brought together, with such deductions, suggestions, or generalizations as seem warranted. The accurate drawing and stating of these conclusions is one of the most delicate steps in preparing a scientific paper, requiring not only caution and discrimination but unusual care in wording to avoid possible misunderstanding.

EDITORIAL REVIEW.

After the paper has been entirely written, revise it clearly for the plan and method of presentation, and for the form of statement. This will frequently result in shortening the

paper and making it more direct in its treatment, and it will give opportunity for the weighing of each statement for accuracy and clearness. If possible have some one else read it who has technical knowledge of the subject. Prefer criticism before rather than after publication. It is usually more agreeable.

Most institutions or organizations now have provision for some editorial review of the manuscript before it is sent to the printer. The editor's task is a delicate one. It calls for tact, sympathy, and patience, but he is in a position to render a real service to writers of technical papers, and his efforts should be welcomed and given respectful consideration.

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